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Endovascular Repair for Thoracic Aortic Pathologies—Early and Midterm Results

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OBJECTIVE: To assess the early and midterm results of endovascular stent graft repair in patients with thoracic aortic pathologies.

METHODS: Between March 2000 and December 2005, 44 consecutive patients undergoing endovascular repair for 45 thoracic aortic lesions were studied. Follow-up protocol includes regular clinical examination and computed tomographies.

RESULTS: There were 37 men and 7 women with a median age of 59 years at operation (range, 26–90). The pathologies consisted of 15 thoracic aortic aneurysms, nine pseudoaneurysms, 16 thoracic aortic dissections, and five thoracic aortic injuries. Successful deployment of the endovascular stent grafts with complete sealing of the pathology were achieved in all but one patient who had the procedure abandoned as a result of access difficulty, giving a technical success of 98%. The median hospital stay was 7 days (range, 3–196), with no hospital death nor paraplegia. The median follow-up was 25 months (range, 0–86). There were eight follow-up deaths, two of which were thoracic aortic pathology related (both patients had aortoesophageal fistulae). There were three other clinical failures: distal attachment endoleak in a patient with thoracic aortic aneurysm, one enlarging and one newly developed dissecting thoracic aortic aneurysm despite endografting. The cumulative freedom from clinical failure and failure free survival were 90% and 75% at 18 months respectively.

CONCLUSION: Endovascular stent graft repair is a feasible option in thoracic aortic pathologies with promising early and midterm results. [*Asian J Surg* 2009;32(1):39–46]

Key Words: aortic, endovascular, thoracic

Introduction

Thoracic aortic diseases carry a high surgical risk. A mortality of 6–69% has been reported for graft replacement in acute Type B thoracic aortic dissection,[1] while thoracic aortic aneurysm repair also carries significant risk with an operative mortality of 15.1% reported recently.[2] This is the result of the magnitude of surgery which typically involves open thoracotomy, extracorporeal circulation and aortic cross-clamping in a group of patients with multiple coexisting medical conditions. Major morbidities, especially spinal cord ischaemia, are also a concern. An overall incidence of lower limb paraparesis/paraplegia of 16% was noted in the Houston experience of more than 1,500 patients with thoracoabdominal aortic repair.[3] In the recent decade, endovascular stent graft repair has

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been introduced as a less invasive alternative for treating abdominal aortic aneurysms, with a reduced perioperative mortality and morbidity.[4,5] This treatment strategy has also been extended to various thoracic aortic pathologies including aneurysm,[6,7] pseudoaneurysm,[8] dissection[7,9] and trauma.[10]

Endovascular repair has been our preferred treatment for thoracic aortic diseases. We aimed to assess the early and midterm results of this approach.

Patients and methods

Between March 2000 and December 2005, 44 consecutive patients with 45 thoracic aortic lesions underwent endovascular stent graft repair after obtaining informed consent. One patient had two synchronous infected thoracic aortic pseudoaneurysms. All the procedures were performed in the operation theatre, with the image guidance of a mobile C-arm Philips BV-29 (Philips Medical System, The Netherlands) or OEC 9800 (General Electric Company, Fairfield, CT). In patients with inadequate proximal landing zones (< 2 cm), intentional coverage of the origins of left subclavian arteries were carried out without prior revascularisation. Further surgical debranching of the aortic arch was carried out if necessary. An endograft with 10–20% oversizing of the landing zone was selected. Postoperatively, patients were assessed regularly with clinical examination and follow-up computed tomography (CT) was performed 1 month postoperatively as well as every 6 months in the first 2 years and at least yearly thereafter. The demographic data, perioperative details and follow-up data were prospectively collected. Cumulative data on clinical failure and the failure free survival were evaluated with Kaplan-Meier analyses.

Results

There were 37 men and 7 women with a median age of 59 years at operation (range, 26–90 years). One procedure for a small thoracic aortic aneurysm in an 81-year-old lady was abandoned due to access difficulties and the patient did not consent to an iliac conduit. Deployment of the endovascular stent grafts with successful sealing of the aneurysm/pseudoaneurysm or aortic tear/injury were achieved in all the other patients giving a primary technical success of 98%. The patient comorbidities and the details of the pathology are listed in Table 1.

Table 1. Patient comorbidities and the pathology of the 44 patients with thoracic aortic diseases

	n = 44
Comorbidities	
Smoker	17
Hypertension	28
Diabetes mellitus	4
Cardiac diseases	15
Stroke	2
Renal impairment	12
ASA class	
I	1
II	16
III	19
IV	7
V	1
Pathology	
Aneurysm	15
Pseudoaneurysm	9*
Dissection	16
Trauma	5

*One patient had two concomitant thoracic aortic pseudoaneurysms.
ASA = American Society of Anesthesiologists.

Pathologies

Two patients had leaking thoracic aortic aneurysms. All the thoracic aortic pseudoaneurysms were due to infection except one that was an anastomotic pseudoaneurysm which developed after a previous thoracic aortic interposition graft for aneurysm repair. Three of these patients presented with massive haematemesis: due to aorto-esophageal fistulae in two patients, with advanced carcinoma of the oesophagus in one and primary mycotic thoracic aortic pseudoaneurysm in the other, and as a result of aortojejunal fistula complicating anastomotic leakage in another patient with jejunal interposition after resection for carcinoma of the oesophagus. One patient had two synchronous infected aortic pseudoaneurysms operated on at the same setting. In the 16 patients with thoracic aortic dissection, two had localised dissection while the others had typical Type B thoracic aortic dissection involving the whole descending thoracic aorta. Seven patients were operated on within 6 weeks of diagnosis for persistent symptoms, including one with a leaking thoracic aortic dissection. The remaining nine patients were chronic dissections (three patients with aneurysmal

Table 2. Perioperative details of the 43 patients with successful deployment of endografts

	Median (range)
Anaesthesia (local:general)	4:39
Operating time (min)	150 (60–480)
Duration of image intensifier (min)	8.8 (2.5–23.5)
Contrast used (mL)	120 (40–250)
Blood loss (mL)	150 (50–3,500)
Need for transfusion	8
Volume of blood transfusion (mL)	0 (0–3,600)
Need for ICU stay	25
ICU stay (d)	1 (0–23)
Hospital stay (d)	7 (3–196)
Types of stent graft deployed	
AneuRx	3
Talent	10*
Zenith	25
Excluder	3

*One patient had two concomitant thoracic aortic pseudoaneurysms treated with Talent grafts. ICU = intensive care unit; AneuRx = Medtronic AVE Inc., Santa Rosa, CA; Talent = Medtronic AVE Inc., Santa Rosa, CA; Zenith = Cook, Bloomington, IN; Excluder = WL Gore, Flagstaff, AZ.

degeneration and six patients with persistent false lumens and compromised true lumens). Another five patients sustained blunt trauma with thoracic aortic injuries.

Perioperative details

The perioperative details are shown in Table 2. Concomitant open procedures were required in nine patients, including four iliac conduits for access (all in female patients), two concomitant open abdominal aortic aneurysm repairs, and three hybrid procedures with surgical debranching of the aortic arch in order to secure adequate proximal landing zones. The origins of the left subclavian arteries were covered intentionally in 15 patients (35%) without prior revascularisation. Additional bare metal, self-expanding Z-stents (Cook, Bloomington, IN, USA) were put into the true lumen distal to the endografts in six patients with thoracic aortic dissection, with an aim of supporting the true lumen and stabilising the dissection flap. The secondary re-entry tears were left undisturbed in the patients with aortic dissection.

Intraoperative angiograms showed successful exclusion of the pathologies in all patients. Blood loss was mainly from valves of the deployment sheaths. Eight patients (19%) required blood transfusion, including one requiring 12 units of blood as a result of an intraoperative anastomotic dehiscence in a patient undergoing surgical de-branching of the aortic arch with ascending aorta to innominate/left common carotid bypass.

All patients were discharged alive with no hospital mortality. The median hospital stay was 7 days (range, 3–196). A patient with thoracic aortic injury (attempted suicide by jumping from height) stayed in the hospital for more than 6 months due to severe concomitant brain injury. Complications occurred in seven patients (16%), including cardiac arrhythmia in four, pneumonia in two, and one each of congestive heart failure, groin wound infection, pseudomembranous colitis and acute cholangitis. The patient with thoracic aortic injury after attempted suicide also developed acute renal failure requiring permanent renal replacement therapy. There was no paraplegia nor a neurological deficit as a consequence of spinal ischaemia or coverage of the left subclavian arteries.

Follow-up

The median follow-up was 25 months (range, 0–86). There were eight follow-up deaths, including two patients with aortoesophageal fistulae where the fistula tracts were persistent, three patients with terminal malignancy and one patient each with myocardial infarction, pneumonia and massive stroke. There were three other clinical failures apart from the two patients with aortoesophageal fistulae; one patient with thoracic aortic aneurysm who developed a distal attachment endoleak, one patient with an enlarging aneurysm sac and one with a newly developed dissecting thoracic aortic aneurysm despite endografting. The cumulative rate of freedom from clinical failure was 90% at 18 months while that for failure free survival was 75% at 18 months.

Aneurysm

With a median follow-up of 21 months (range, 2–71), there were two deaths (one from carcinoma of the lung and the other from myocardial infarction). The aneurysm sacs were well thrombosed except in an 84-year-old man who developed a distal attachment endoleak on follow-up as a result of an inadequate distal landing zone. The patient declined further intervention. Ten aneurysm sacs (71%) decreased in size (median of decrease, 10 mm;

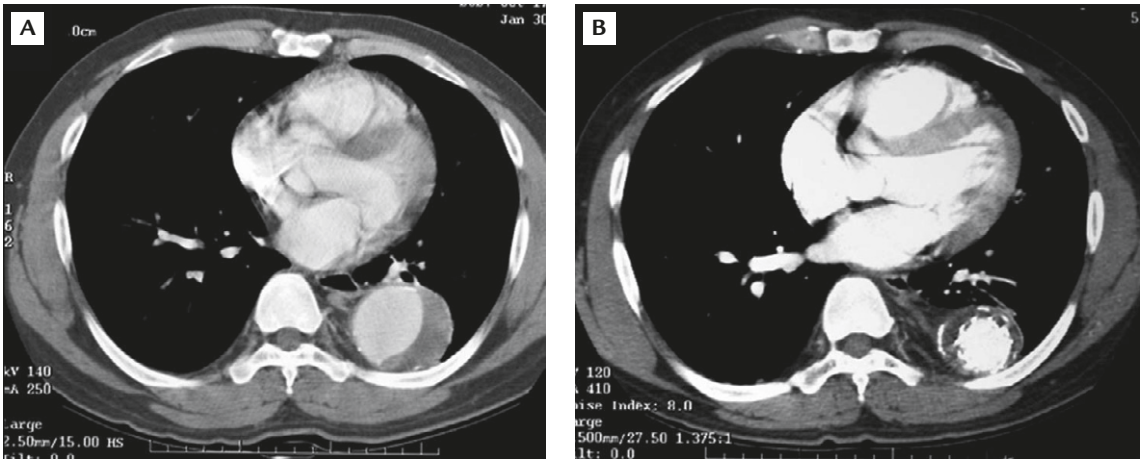

Figure 1. Computed tomographies showing decreasing size of the aneurysm sac after endovascular stent graft repair: (A) preoperative; (B) 4 years after operation. Note the complete thrombosis of the sac with no endoleak.

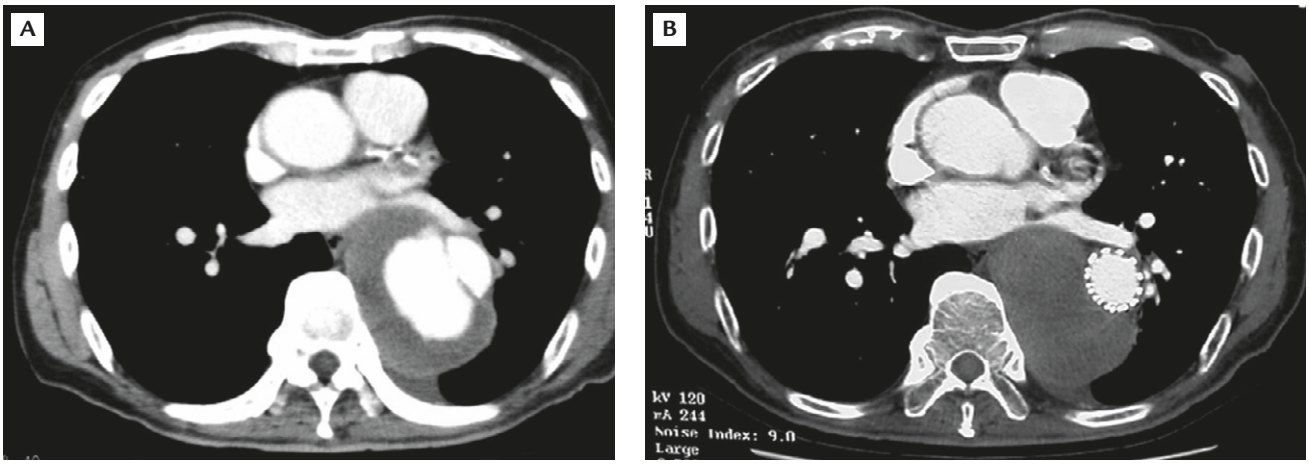

Figure 2. Computed tomographies showing an infected thoracic aortic pseudoaneurysm with complete thrombosis of the sac after endovascular repair: (A) preoperative; (B) 6 months after operation.

range, 1–28 mm), with the majority (90%) showing a significant reduction (≥ 5 mm) (Figure 1).

Pseudoaneurysm

With a median follow-up of 17 months (range, 3–56), there were four follow-up deaths. Two patients had persistent oesophageal contamination to the stent grafts and they died of graft infection and haematemesis 3 months after the initial stent graft placement. The other two patients died of pneumonia and massive stroke respectively. The three remaining patients with infected thoracic aortic pseudoaneurysms were all kept on life-long maintenance oral antibiotics according to the culture results with consultation to the microbiologist. They remained well with no evidence of graft infection at follow-up 56 months, 54 months, and 52 months after the operation respectively. Follow-up CT was performed on each patient, with no evidence of late graft infection detected. Thrombosis of the pseudoaneurysm sacs with a significant reduction in sac size (≥ 5 mm) was also noted in all patients with infected pseudoaneurysms who had a follow-up of more than 6 months including the two patients who died of pneumonia and stroke (Figure 2). The other patient with an anastomotic pseudoaneurysm also had complete thrombosis of the sac although the sac size remained static.

Dissection

With a median follow-up 26 months (range, 13–86) there were two deaths from malignancy. Eleven patients (69%) had the thoracic aortic false lumen at the stented region completely healed (Figure 3), including the two patients with localised dissections. Two other patients had only partial thrombosis of the false lumen. One of them had a tear into the false lumen at the distal stent graft attachment

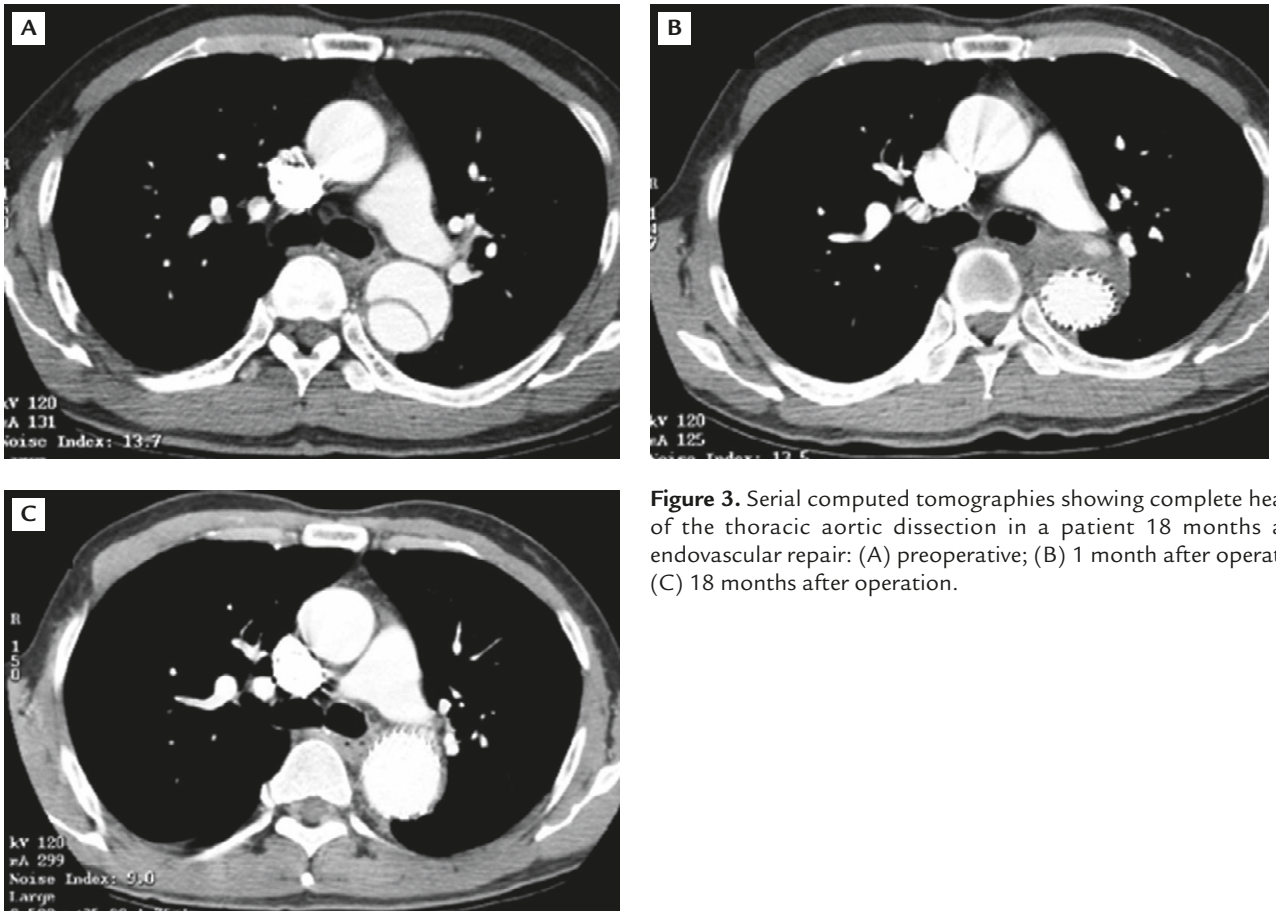

Figure 3. Serial computed tomographies showing complete healing of the thoracic aortic dissection in a patient 18 months after endovascular repair: (A) preoperative; (B) 1 month after operation; (C) 18 months after operation.

site with subsequent aneurysmal degeneration. Additional distal stent graft to cover the tear was planned. In the remaining three patients who presented with aneurysmal degeneration, the false lumen thrombosed completely in two with significant decrease in the size of the dissecting aneurysms (> 10 mm). In one patient with a dissecting aneurysm over the lower thoracic aorta, the false lumen remained patent due to the distal secondary tear resulting in continued increasing size of the aneurysm despite successful coverage of the primary tear at the proximal descending aorta. Open conversion was arranged. Secondary re-entry tears were left undisturbed resulting in persistent false lumens in the abdominal aorta in the majority of patients (81%). Endovascular coiling was required in one patient with endoleak from retrograde flow of the left subclavian artery.

Trauma

All the five patients with thoracic trauma were alive at a median follow-up of 32 months (range, 0–65). One patient, being a tourist, went back to his home country and did not attend follow-up. CT before his discharge showed healing of the aortic injury. The other four patients were alive with healed aortic disruption although one of the patients was institutionalised because of severe concomitant brain injury. Figure 4 shows the CT and intraoperative angiograms before and after endovascular stent graft repair in a patient with thoracic aortic injury.

Discussion

Endovascular stent graft repair appears to be a safe option in patients with thoracic aortic pathologies as judged by the zero hospital mortality in this group of 44 consecutive patients. It obviated the need for thoracotomy, significant blood loss, aortic cross-clamping, and extra-corporeal circulation in these patients with multiple concomitant medical comorbidities, where a large proportion (61%) had an ASA (American Society of Anesthesiologists) classification III or above. Our early results compare favourably with that from the largest series of thoracic endografting reported by the EUROSTAR and UK Thoracic Endograft Registries, where an overall 30-day mortality of 9.3% and a paraplegia/paraparesis rate of 2.5% were noted.[11] Apart from

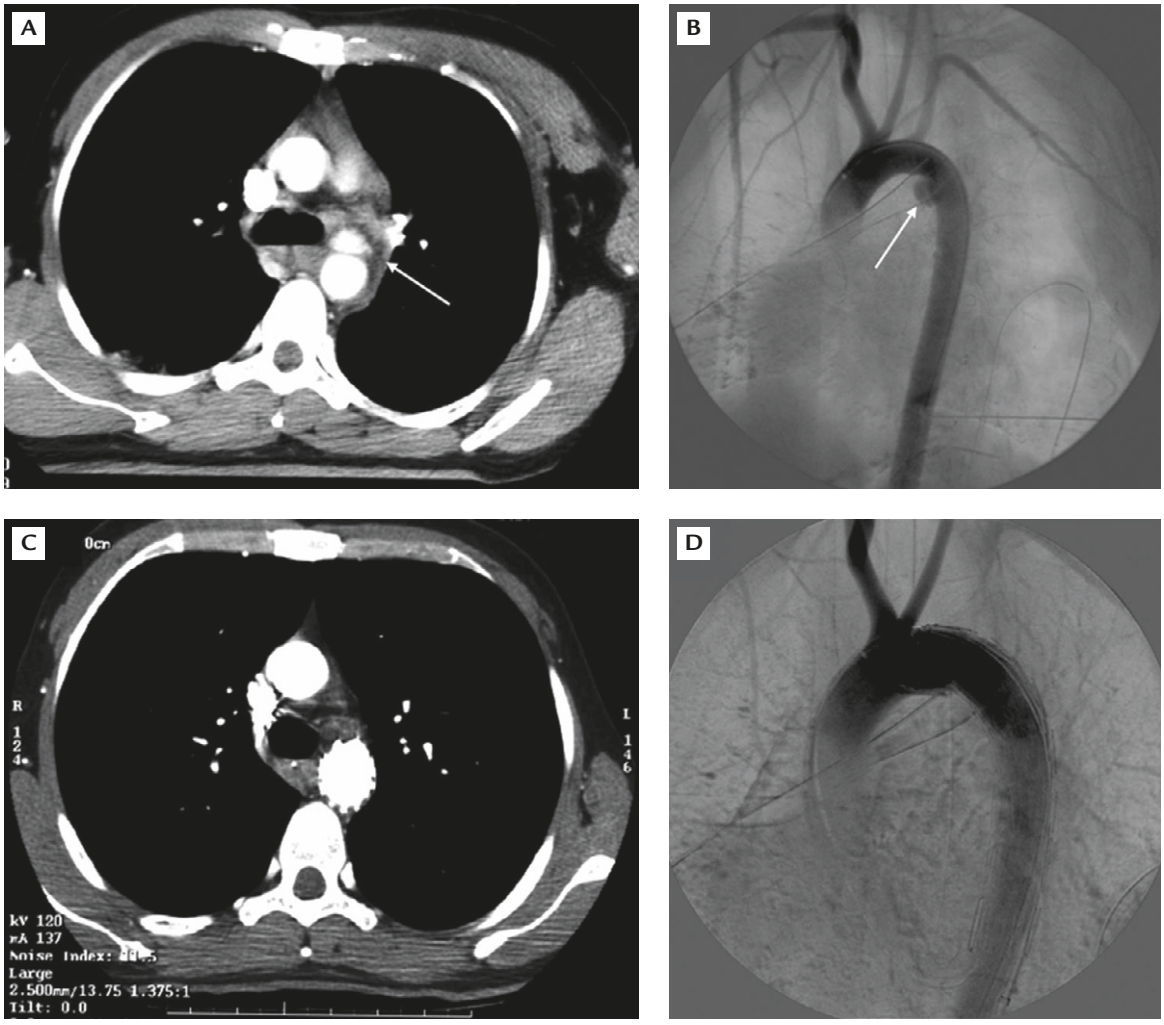

Figure 4. Computed tomographies and intra-operative angiograms showing the typical aortic disruption (arrow) in a patient sustaining deceleration injury. Complete sealing of the tear was achieved after endografting: (A) preoperative computed tomography; (B) intra-operative angiogram showing the aortic disruption; (C) computed tomography 1 month after repair showing complete healing of the aortic disruption; (D) intra-operative angiogram showing complete sealing of the aortic tear after endografting.

being immediately life-saving for the patients with leaking aneurysms or aortic disruptions, the midterm results are also promising as there were only two aortic pathology-related mortalities at a median follow-up of 25 months. The two patients with aortoesophageal fistulae died 3 months after endografting. Their demises were not unexpected given the persistent oesophageal contamination as a result of the lack of definitive surgery. The cumulative clinical success, i.e. freedom from clinical failure such as attachment leaks, sac enlargement etc., was also remarkable with 90% at 18 months.

Traditionally, medical management has been the standard for uncomplicated Type B thoracic aortic dissection because of the high risk of open repair. Nevertheless, with medical therapy, the mortality still reached 20%[12] with more than 30% developed aneurysmal changes at 3-year follow-up.[13] The concept of endovascular stent graft repair appears appealing as it achieves the goal of surgical treatment by covering the aortic tear and thus depressurising the false lumen. It induces false lumen thrombosis and remodelling with "healing" of the aorta, as well as enlargement of the true lumen. Such an approach may effectively treat malperfusion syndrome (at least those caused by dynamic obstruction), and theoretically reduce late aortic-related complications by minimising the incidence of aneurysmal degeneration.[1] In the landmark study reported by Dake in 1999, 19 patients with thoracic aortic dissection were treated by endovascular means with a 100% technical success and complete false lumen thrombosis achieved in 79%.[9] We showed a similarly promising result with 69% of the thoracic false lumen healed at a median follow-up of 26 months, although there were two

clinical failures. There was a new aneurysmal degeneration developed in a patient who had only partial thrombosis of the false lumen as a result of a tear into the false lumen at the distal landing zone and there was another patient with a patent false lumen at the distal thoracic aorta with increasing size of the dissecting aneurysm. In a recent report comparing medical treatment with endovascular repair for Type B thoracic dissection, aneurysmal dilatation of the descending thoracic aorta was much more frequent in those with medical therapy (28.5% *vs.* 3.5%).[14]

Most patients still had patent secondary re-entry tears resulting in persistent false lumen in the abdominal aorta. Some believe that this may not necessarily be detrimental because, unlike the thoracic segment, the abdominal false lumen does not appear to have a propensity for aneurysmal dilatation.[15] However, as noted in our patient with distal dissecting thoracic aortic aneurysm, continued perfusion of the lower thoracic false lumen may occur as a result of the distal secondary tear, leading to continued increasing size of the dissecting aneurysm despite coverage of the primary tear. Further research on this aspect is required.

Although our current results and those from other reports[15–17] have shown favourable outcomes in patients with thoracic aortic dissection receiving endovascular repair, as with all new therapies, randomized controlled trials would be the ultimate answer. This would be addressed by the INSTEAD trial, which compared the outcome of uncomplicated type B aortic dissection when treated by endovascular stent grafting adjunctive to best medical treatment versus best medical treatment alone.[18] Preliminary trial results, however, showed no survival benefit from stent grafting after the first year.[19]

Endovascular repair for infected aortic pseudoaneurysm is more controversial. There has always been a concern about persistent infection by putting a stent graft in an infected field. However, even with open repair, *in situ* prosthetic reconstruction was often unavoidable. Long term follow-up (> 50 months) in three of our patients with four infected aortic pseudoaneurysms showed no clinical evidence of sepsis with complete exclusion of the pseudoaneurysms and significant reduction in the sac size. We believe that potent antibiotics with life-long maintenance together with regular surveillance using computed tomographies are indispensable.[8]

Adequacy of a proximal landing zone (> 2 cm) is always a concern in endovascular repair of thoracic aortic pathologies. Intentional coverage of the origins of the left subclavian artery was required in 15 patients (35%) with additional aortic arch de-branching performed in three of them. There were no adverse neurological events. Although posterior circulation stroke is always a possibility, opinions diverge about the need for extra-anatomic revascularisation of the subclavian artery under these circumstances. There are proponents of routine subclavian revascularisation when intentional coverage of the left subclavian origin is required,[20,21] while others believe that coverage of the left subclavian artery is generally well tolerated even without revascularisation owing to the extensive collateral blood supply to the arm.[22,23] Nienaber from Germany[24] advocates a more selective approach and considers revascularisation only in those who develop ischaemic symptoms or who have a potentially compromised collateral circulation as shown in preoperative imaging of the supra-aortic arteries. Although none of our patients had neurological events, one patient with thoracic aortic dissection developed a Type II endoleak via the retrograde flow from the covered left subclavian artery requiring subsequent endovascular coiling.

In summary, endovascular stent graft repair is a feasible option for patients with thoracic aortic pathologies including aneurysm, pseudoaneurysm, dissection and trauma, with promising early and midterm results. However, further confirmation is required by longer follow-up and the need for continued surveillance cannot be overemphasised.

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